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PERIODONTICS

# Ultrasonic Probing:
## *The Wave of the Future in Dentistry*

By Cheryl Farr

Imagine this: the Navy, NASA, and the National Institute of Dental and Craniofacial Research working together to develop a breakthrough dental technology. This technology, an ultrasonic intraoral probe, may enable a strategic leap forward in the detection and monitoring of periodontal disease. By noninvasively detecting, imaging, and mapping the upper boundary of the periodontal ligament, patient discomfort and the need for premedication (sometimes associated with conventional manual probing) are eliminated.

The probe is placed at the gum line and the ultrasound is projected into the periodontal tissues. The ultrasonic echoes are recorded by the probe and processed in the computer with artificial intelligence software.

While ultrasonic imaging has long been recognized as having excellent potential in periodontal tissue evaluation, initial attempts at using ultrasound failed. Major technical difficulties have now been overcome by adapting an ultrasound used to find structural flaws in aircraft. The new periodontal probe is small enough to be useful, yet transmits and receives sufficient signal strength. In an interview with *Dentistry Today*, the probe's major developer, Dr. Mark Hinders, explained how the probe works. "The device projects a narrow beam of ultrasonic energy down between the tooth and bone from a transducer, which is manually scanned along the gingival margin."

The new ultrasonic instrument is now on a pathway headed for the general dental market. The NASA patent has been licensed by Visual Programs, Inc, in Richmond, Va. (804-935-0417). Field testing, laboratory testing, and various stages of refinement have been completed. The final two checkpoints are pilot testing and clinical trials, which are scheduled to start this summer. Assuming that FDA approval follows, the development of an ultrasonic alternative to conventional periodontal probing promises a better understanding of the pathogenesis of periodontal disease.

In addition to eliminating often-reported discomfort associated with conventional periodontal probing, the ultrasonic probe may provide more significant diagnostic results. If this is proved in clinical trials, dentistry will have a new technology that could create a magnitude improvement over what is available today. This new device may someday be celebrated as one of the major steps forward in the battle with periodontal disease.

## SIMPLE, PAINLESS, NO RISK TECHNOLOGY

"The ultrasonic probe works somewhat like a sonogram," according to Dr. Mark Hinders, who is on the development team. "With a sonogram, the probe is pressed against the body and the beam penetrates the womb and the echoes that come back are recorded and displayed as an image of the fetal face. What we've done is adapt that same technology to image the periodontal structures, mainly by making the probe that sends the ultrasound signals and receives the echoes very small. The rest of the instrumentation is contained within a standard PC and the entire measurement is computerized."

While ultrasound is a standard diagnostic technology in many areas of medicine, this is the first application of ultrasound (diagnostically) to dentistry. In addition to registering pocket depth, which is only a retrospective analysis of attachment already lost, other significant information is gathered. "Ultrasound gives more information, because secondary echoes are recorded from tissue features at various depths," said Dr. Hinders. "Ultrasound is quite sensitive to changes in tissue due to inflammation and other conditions."

It appears likely that the technique will also be able to provide information on the condition of the gingival tissue and the quality and extent of the epithelial bond to the tooth surface. According to Dr. Hinders, "Subtraction radiography (X-rays) may be of value in detecting small changes in alveolar bone mineralization, but it does not evaluate periodontal ligament attachment. In addition, changes in bone have been shown to lag behind connective tissue loss by several months. Serial radiography subjects the patient to increasing amounts of ionizing radiation. The probe will provide a method for detecting small increments of periodontal ligament breakdown. This may permit earlier diagnosis and intervention with less costly and time-consuming therapies."

Dr. Hinders also pointed out that there is evidence that "disease active" sites respond positively to therapy, but that quiescent or stable sites do not change or lose attachment. "A more sensitive diagnostic intraoral probe would permit site-specific identification of attachment loss. This could direct treatment toward areas that are actively breaking down, and eliminate over-treatment for sites that are stable. The ultrasonic probe may therefore yield valuable data to aid the clinician in the diagnosis and treatment charting of the disease," said Dr. Hinders.

## DEVELOPMENTAL RESEARCH

Most of the basic research on how ultrasound propagates in biological media was done throughout a 20-year period from the mid-40s to the mid-60s. Multiple instruments were developed for generating, detecting, and measuring ultrasound during these years. In addition, crucial details regarding how ultrasound propagates in biological media were discovered. These propagation properties are important for diagnostic, as well as therapeutic and surgical use of ultrasound. Speed of sound absorption, attenuation, scattering, and impedance were determined.

In addition, the physical mechanisms of interaction of ultrasound were studied in some detail and phenomenological theories were developed. Toxicity and dosimetry were treated in detail, and nonlinear acoustic properties were studied. Measuring methods as well as instruments were invented and developed to their full usable potential. Many of these instruments are still employed throughout the world. While the main use of ultrasound in dentistry is for scaling and internal shaping of teeth, this is in contrast to other areas of medicine where diagnostic ultrasonography is a standard clinical imaging technology.

In dentistry, one key developmental challenge was finding a way to make an ultrasonic instrument both small enough to meet the special demands of the gingival margin, and powerful enough to image the periodontal space. "We had to develop the probe handpiece to contain a tip that is small enough to permit scanning of the area between teeth, said Dr. Hinders. "The optimal coupling had to be both small enough to inspect the gingival margin and still deliver sufficient signal strength and depth of penetration to image the periodontal space," he added.

There is a very small window afforded by the gingival margin. "The space occupied by the periodontal ligament is normally on the order of 0.5-mm wide, located between the outer surface of the tooth root and the inner surface of the bone forming the socket in which the tooth resides. The coronal elevation of the periodontal ligament is normally approximately 1 mm below the surface of the junctional epithelium that abuts the tooth surface and forms the sulcus below the gingival margin," said Dr. Hinders.

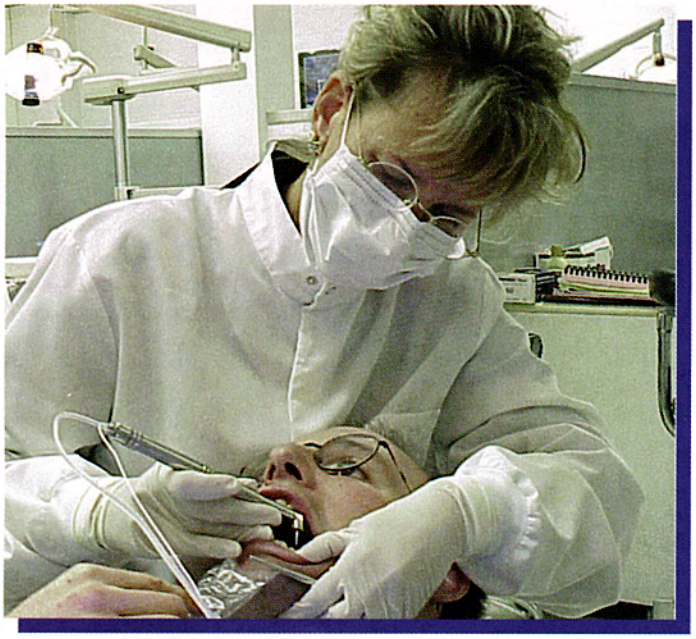
"By mounting a transducer at the base of a dual-taper, convergent-divergent coupler, an acoustically tapered interface with a throat area on the order of 0.5 mm was created," he explained. "A throat area of 1.5 mm represents an active area reduction to what is mandated by the gingival margin." (The ultrasonic transducer is attached to the probe tip shell. A transducer is a sensor that converts signals, such as an ultrasonic wave frequency into an electrical signal. With the transducer, the tip has a throat diameter small enough to project the ultrasonic beam into the narrow space between the tooth and bone.) An added virtue of attaining this small a tip size is the ability of the ultrasonic probe to examine the area between the teeth, which is where the problem of periodontal disease is most likely to occur.

When the probe tip is placed at the gingival margin, ultrasound is projected into the periodontal pocket. The echoes returning from the crest of the periodontal ligament are mapped and charted. "The focused ultrasonic beam is transmitted into the pocket in the same orientation as if a manual probe was inserted," said Dr. Hinders. "The probe is then moved along the gingival margin, so the two-dimensional graphical output corresponds to the output one gets from 'walking the sulcus' with a manual probe."

## IMPLEMENTATION AND SOFTWARE

"During the development of this technology we felt it was critically important to get the input of hygienists, since they will be the ones doing the probing," said Dr. Hinders. "Our goal was to develop not just a diagnostically useful tool, but an instrument that hygienists would actually find easy to use."

Gayle McCombs, a professor in the graduate program for the School of Dental Hygiene at Old Dominion University in Norfolk, Va, will be the coordinator for clinical trials for the instrument. "I'm not the kind of person who jumps on the bandwagon," she said, "But I think this technology may propel the profession into the future. As we know, a lot of patients fear the pain associated with dentistry. With this probe, there is no possibility of causing patient discomfort. In my estimation, the major



Professor Gayle McCombs, MS, RDH, uses the probe on William & Mary PhD student Ted Lynch. Ms. McCombs is the clinical research coordinator for Old Dominion University's school of dental hygiene.

benefit of the probe is that it is completely noninvasive. Not only is it completely painless, but the use of the probe will eliminate the need to premedicate with antibiotics. There will be no possibility of bleeding."

Ms. McCombs also believes the ultrasonic probe will be more time-efficient. "As opposed to inserting a probe in every pocket, a hygienist will only have to slide or glide this instrument along the gums." The probe will not only provide a wealth of information, and eliminate worries about infection control, it will also eliminate any need to write down or manually chart pocket depth, since that will be automatically transmitted to the computer.

"I expect the probe to prove to be more accurate, since operator variability with manual probes can skew pocket depth ratings," said Ms. McCombs. "Absolutely no pressure is used with the instrument, so differences now caused by more pressure exerted during manual probing will be reduced or eliminated. Readings between the lines, in which one hygienist rounds up, the next rounds down, will also be eliminated."

According to Dr. Hinders, "The operation of the instrument is mostly automatic. The first step is for the hygienist to select by means of a foot-pedal the tooth being scanned. Second, the probe tip is placed against the tooth, touching the gingival margin. The narrow ultrasound beam then penetrates the periodontal tissues in the same orientation as if a standard periodontal probe was inserted. Third, the probe is swept along the gum line and the echoes from the periodontal tissues are recorded on the computer. Fourth, the artificial intelligence software in the computer sorts out all of the echoes and makes a cartoon of attachment level, pocket depth, etc, automatically."

The probe tip incorporates a slight flow of water to ensure a good coupling of the ultrasonic energy to the tissues. "The probe can be mounted in a handpiece that is light in weight and a convenient size for clinical use," said Dr. Hinders. "The couplant water can come either from a suspended IV-type sterile bag or plumbed from the dental chair. All the specialized electronics are commercially available as plug-in computer boards and the software will run on Pentium PCs."

Visual Programs, Inc, are developing the software front-end for the ultrasonic probe. Visual Programs personnel are the originators of Chart-It, one of the earliest computerized periodontal charting programs. The eventual goal will be to have the ultrasonic probe fully integrated into charting software. Reading the pocket depth is done by the software, so the operator doesn't have to interpret ultrasound images. All information is automatically recorded and archived on the computer.

According to Dr. Hinders, "The cost of the new probe will be in line with instruments like Florida Probe, although the exact price point has not been determined yet. We want to make it cost-effective and feasible to use in general dentistry practices. The goal is not a specialized instrument strictly for periodontal offices. We envision this as a replacement technology, allowing for full-mouth probing that is quick and easy with a single operator because of the automatic computer archiving. It should be entirely painless for the patient, and more successful at motivating patients for needed treatment because of the easy-to-understand computer graphics output."

While any new technology is subject to ups and downs in its development, many of the crucial challenges in the development of the new ultrasonic periodontal probe have already been met. The use of ultrasound in diagnostics in other healthcare disciplines has greatly extended the diagnostic capabilities of practitioners. At the very least, the use of ultrasound in dental diagnostics will provide an alternative approach to conventional probing. Once the clinical research is completed, the major question will be whether the rewards will exceed the costs and risks. If the new ultrasonic probe fulfills its potential, the common use of office-based portable ultrasound systems for diagnostic imaging may soon expand beyond cardiology, obstetrics, gynecology, urology, family practice, and pediatrics. General dentistry may be the newest field added to the list.✦

Dr. Hinders earned his PhD in 1990 with a degree in engineering from Boston University. From 1986 to 1991 he was a research assistant and research associate in physics and engineering at Boston University. From 1987 to 1991 he was electromagnetics research engineer at Rome Laboratory, Hanscom AFB. From 1991 to 1993 he was senior scientist at Massachusetts Technological Laboratory in Belmont, as well as research assistant professor and adjunct assistant professor of aerospace and mechanical engineering at Boston University. From 1993 to 1999, he was assistant professor of physics and applied science at the College of William and Mary in Virginia. Currently a tenured associate professor of applied science, he is a founding member of that department and head of the nondestructive evaluation group.

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**Ms. Farr** is an expert on high technology. She speaks on the topic internationally, and is well known for her insights about how to use technology and computers to meet the opportunities and challenges in today's dental environment. She has been published in every major dental publication, and has been featured monthly for the past 4 years in *Dentistry Today.* Ms. Farr can be contacted at (831) 429-7727, by fax (650) 365-3689, e-mail at cherylfarr@neteze.com, or visit her home page at www.dentalxchange.com/cherylfarr for her speaking and schedule and consulting.